Electricity in San Mateo County, Cal.

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

CONGRESS

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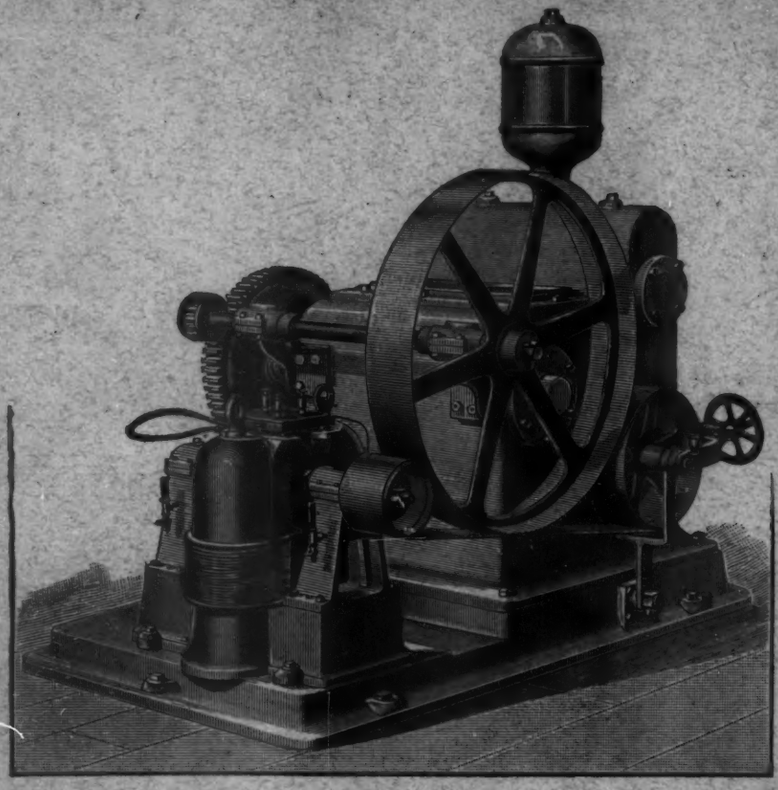

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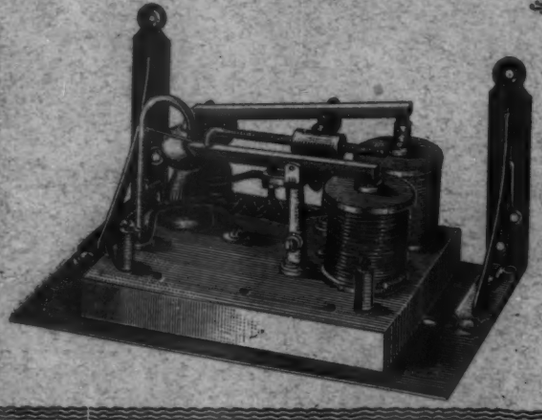

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THE JOURNAL OF ELECTRICITY, POWER AND GAS.

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XI. SAN FRANCISCO, APRIL, 1901. NUMBER 4.

Electricity in San Mateo County, California.

BY C. H. PENNOYER.

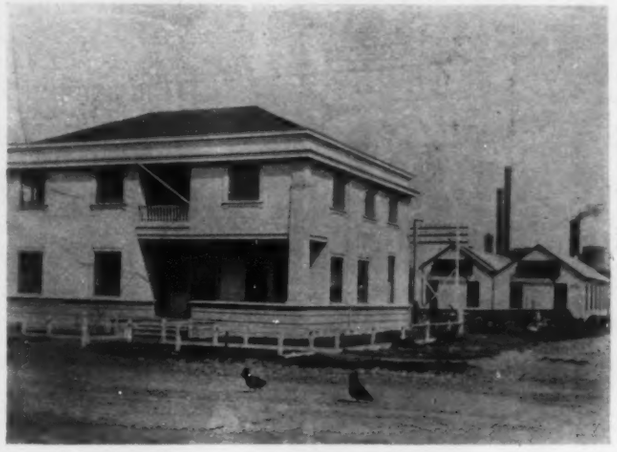
IN the latter part of January, 1900, the then recently incorporated Consolidated Light and Power Company acquired the Peninsula Lighting Company, The San Mateo Electric Company and the San Mateo Gas Light Company, all of San Mateo county, California. The San Mateo Company then operated one 60 kilowatt and one 45 kilowatt single-phase generator, giving an all night service, with about 3,000 lamps connected to its mains in the northern part of San Mateo county, and having distributing systems in Burlingame, San Mateo city and Belmont. The Peninsula Lighting Company operated one 75 kilowatt and one 45 kilowatt single-phase Westinghouse generator, having a connected load of about 3000 lamps, with service continuing until midnight each night. Besides these two companies there were in operation a municipal lighting and pumping plant at Palo Alto, a municipal lighting plant and water works at Redwood City, a lighting and power plant at the Leland Stanford Junior University, a lighting and power plant at Reid's Belmont School, the latter plant being a gasoline engine and Edison generator operated in connection with storage batteries at the residence of J. Le Roy Nickel near Menlo Park.

MAIN OFFICE OF THE CONSOLIDATED LIGHT AND POWER COMPANY, REDWOOD CITY, CAL.

The Consolidated Light and Power Company had not been in the field many days before active canvass was begun to secure the closing down of these private and municipal plants and the acquisition of their owners as its customers, but before they could be supplied with current it was necessary that additional apparatus should be installed and that it should be of such a character as to enable the operation of motors for electric power service.

The Consolidated Company had then and still has a contract with the Standard Electric Company of California to furnish it with current as soon as the Standard transmission lines are extended into San Mateo county, but owing to the non-delivery of the current up to this time, and in order to take on the additional business before its arrival, the following machinery was installed with the least possible delay in the Redwood City station of the Consolidated Company.

One battery Babcock & Wilcox boiler, one 13x19x17 McIntosh & Seymour tandem compound engine, one Wheeler surface condenser, two 150 kilowatt Stanley two-phase generators, one 72 kilowatt Stanley two-phase generator, one 60 kilowatt Westinghouse single phase generator, and one set of Buffalo induced draft apparatus. The steam pipes were all refitted and supplied with high grade valves and the moisture in the steam therein was entrained by use of Stratton separators.



MAIN OFFICE, WITH REDWOOD STATION IN THE BACKGROUND.

The Redwood City powerhouse is situated on the

MAIN GENERATING STATION AT REDWOOD CITY.

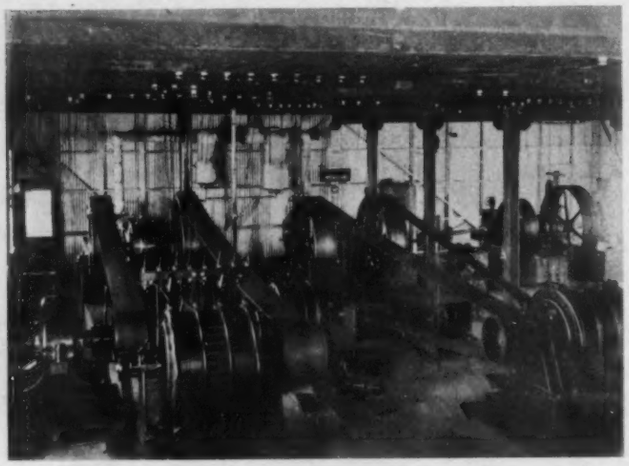
bank of Redwood Creek, thereby enabling its operation as a condensing plant and also insuring minimum freight rates on fuel, which is delivered by schooners or barges directly into the company's bunkers. This station contains besides the foregoing, a 12x20x18 tandem compound high speed engine and one 10x14x12 slide valve engine, two 60x16 inch fire tube boilers, one 75 kilowatt and one 45 kilowatt Westinghouse single-phase generator, one 50 kilowatt Brush single-phase generator of the revolving field type.

The San Mateo station contains two tubular boilers and two 9x12x12 tandem compound high speed engines, one 72 kilowatt Stanley two-phase generator, and one

REDWOOD CREEK, SHOWING REAR OF THE REDWOOD STATION.

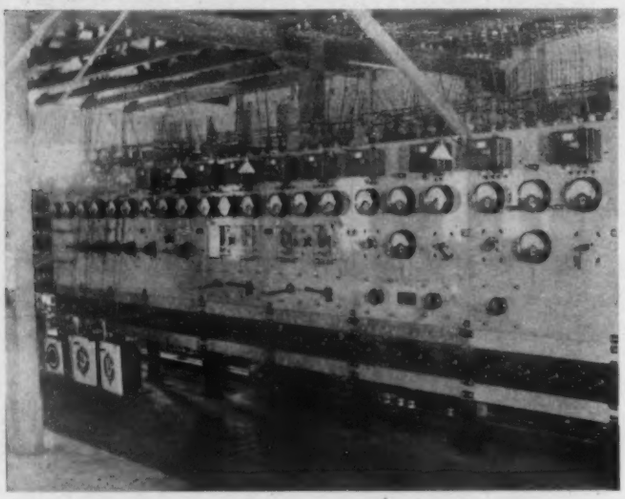
60 kilowatt Westinghouse single-phase generator, which are operated to carry the lighting load over a peak that lasts about three or four hours every night. At other times the San Mateo station serves as a substation, for which purpose it also contains two 60 kilowatt lowering transformers, each of which is provided with taps brought out for regulation and connected to heads for that purpose.

The current is generated at a pressure of 5,500 volts at the Redwood City Station, whence one feeder, consisting of 4 No. 4 aluminum wires, conveys power to the step down transformer at the San Mateo Sub-Station, where it is lowered to 2,200 volts for distribution. Another feeder, composed of four No. 4 copper wires, carries the current from Redwood south to the Palo Alto sub-station. This sub-station is simply a small brick transformer house where the voltage is stepped from 5,500 volts to 2,200 volts (ratio 2½ to 1); from this point a two-phase four-wire line runs to the Stan-



NEW ENGINES AND STANLEY GENERATORS IN THE REDWOOD STATION.

ford University power house, whence the current is distributed to the various University buildings. Other lines run from the transformer house to the town of Palo Alto, Mayfield, and Mountain View, and the University Campus. The main north and south lines running from the Redwood City power house are trunk lines from which no lighting service connections are made, as they are alive throughout the twenty-four hours of each day and every day. Power service is, however, taken from them. The lighting circuits are so arranged that they can be cut out of service during the day time, thus saving the core losses for at least twelve

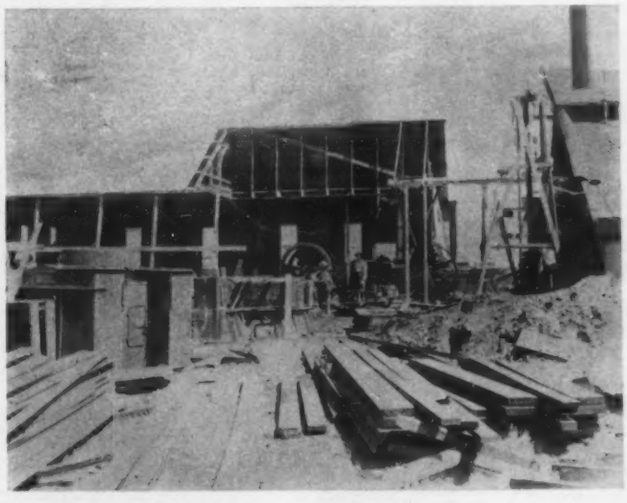


SWITCHBOARD IN THE REDWOOD STATION.

EXCAVATING FOR FOUNDATIONS IN REBUILDING THE REDWOOD STATION.

hours per day; besides the day consumption of current for light does not warrant this waste.

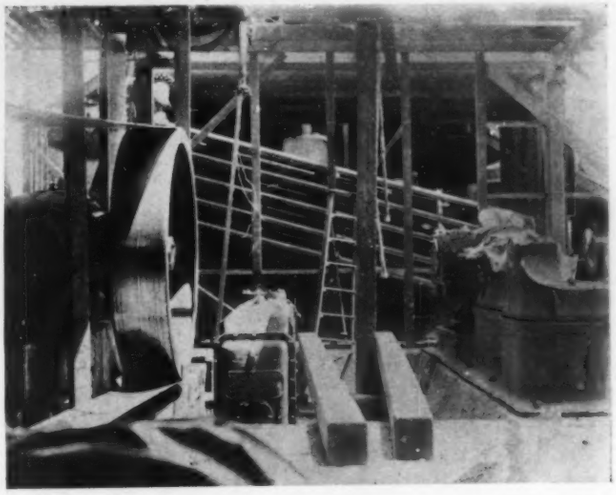
Owing to the numerous tall trees which line the sides of the county roads in both San Mateo and Santa Clara Counties, it was necessary to use very tall poles in order to clear them. The north feeder is carried nearly the entire distance of eight miles betwen the power house and sub-station on 45-feet poles, some poles being 55 and even 60 feet in length. The same difficulty was encountered on the South feeder. The trees are very highly prized by the owners of property abutting these



DRIVING PILES FOR THE BOILER FOUNDATIONS.

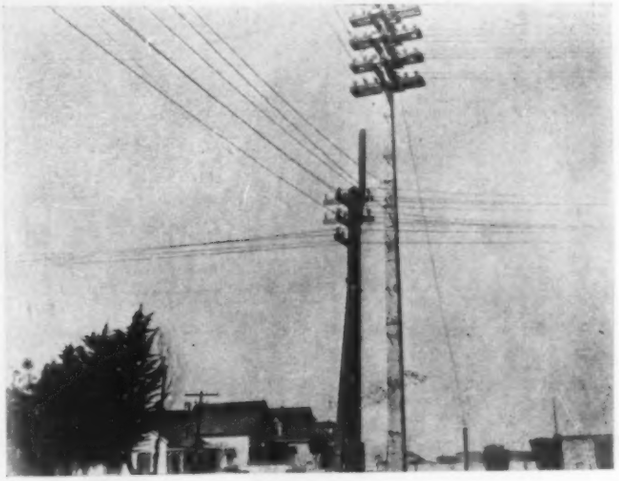
roads, and it would be considered an unpardonable barbarity by the community to attempt to trim, much less to cut down, any of them. These poles are all sawed redwood, planed and painted, averaging 7x7 at the top, by 13x13 at the butt. The cross arms are 4x6 sugar pine, and each contain four 12x1 15-16 eucalyptus pins, previously boiled in oil. The insulators are of the Locke triple-petticoat glass type, 4½ inches in diameter, while the pins were made by the Hardwood Planing Mill Company, of San Jose. Secondary three-wire systems are employed wherever the consolidation of customers will permit it.

In May, 1900, a contract was made with the municipality of Redwood City to furnish it with electric current for street lighting and electric power for pumping water for its water supply. Its old plant contained a small series Brush arc machine furnishing current to lamps of the same make. The pumping plant consisted of an air compresser to operate an air lift and two direct acting



NEW MACHINERY WAS ERECTED IN THE OPEN AIR WITHOUT SHUTTING DOWN.

steam pumps. In order to improve the street lighting system and enable the Consolidated company to furnish it with current, General Electric enclosed alternating current, constant potential arc lamps with, in the main, individual transformers, were recommended by the Company and installed by the Town, the series arc lamps being removed. In the main well at the water works a direct acting deep well pump was substituted for the air lift. This pump has a capacity of 20,000 gal-

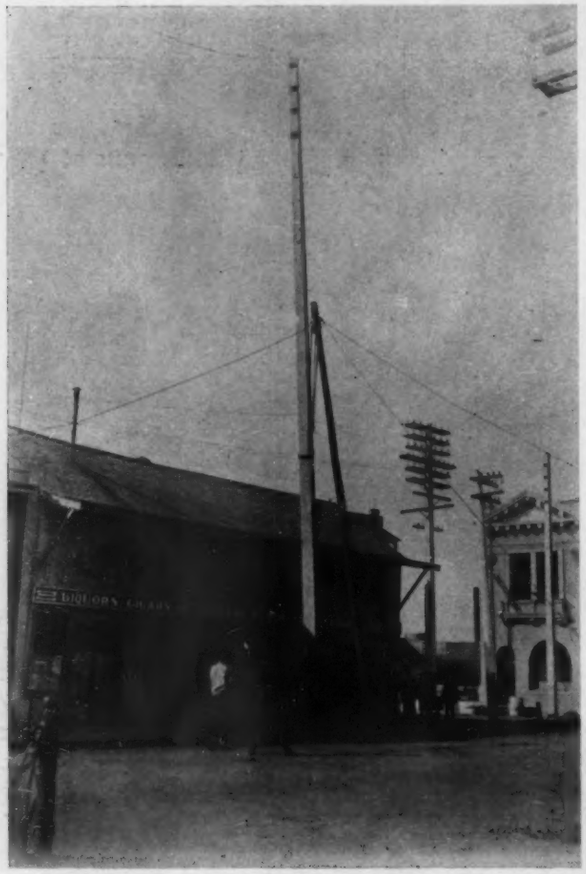


A POLE OF THE OLD AND A POLE OF THE NEW SYSTEMS.

lons per hour and is geared to a 20 horse-power Westinghouse induction motor. The plant has given the best of satisfaction, and results in a considerab'e saving to the municipality over the operation of its own plant.

At the Belmont School a steam plant, consisting of a Babcock & Wilcox boiler, a 50 horse-power Ideal engine and a 30 kilowatt Edison generator, and several gasoline engines as well, were replaced by current purchased from the Consolidated Company to operate motors and furnish light, the motors being used for operating pumps and laundry machinery.

Prior to the advent of the service of the Consolidated Light & Power Company, the Leland Stanford Junior



RAISING A SIXTY-FOOT POLE AT REDWOOD CITY.

University was operating a connected load of 6,600 lights and running 35 horse-power in motors in its shops. The Conso'idated Company secured this load, together with a contract for furnishing the entire future lighting and power load of the University, with an order to change all of the transformers from 125-cycle Brush to 60-cycle modern types, and also to furnish eighty-five horse-power in induction motors. These are all of the General Electric Company's "Form L" type. A motor-generator set, consisting of a fifteen horse-power induction motor direct connected to a 12½ kilowatt General Electric compound wound direct current generator, both mounted upon a cast iron base, was installed

THE SAN MATEO STATION AND COMPANY'S LOCOMOBILE.

for furnishing 110 vo't direct current for laboratory purposes and for supplying current for the direct current variable speed motor which is to operate the large organ in the Memorial Chapel.

The wood-working shop is driven by a twenty horse-power motor, and the foundry and blacksmith shop are each driven by a ten horse-power.

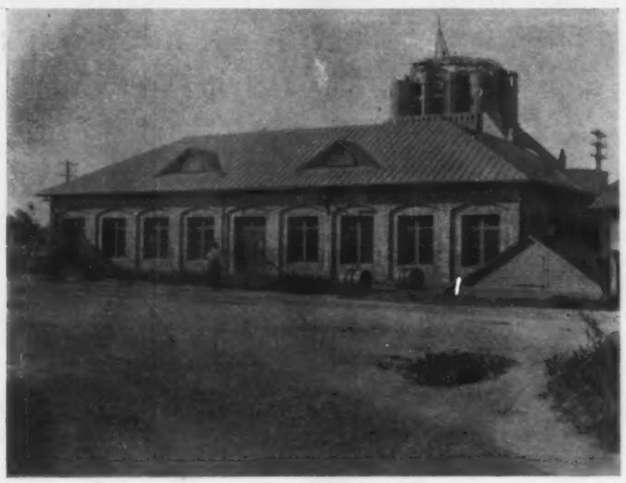
At the pumping works a Byron Jackson centrifugal pump is direct driven by a ten horse-power motor. This pump raises the water to the surface and discharges it into a settling tank, from which it is e'evated about 600 feet by a Worthington duplex pump geared to a twenty horse-power General Electric motor. The water is conveyed about two miles through an 8-inch pipe to the reservoir in the hills back of the University.

On the farm of Walter S. Hobart, at San Mateo, the

TYPICAL OF THE DISTRIBUTION IN MENLO.

electric motor plays a very important part. Out in the tank house a 7½ horse-power Westinghouse induction motor has replaced a gasoline engine for driving a deep well pump. In the stables a feed cutter and a circular saw are each driven by a 3 horse-power Westinghouse motor and a half horse-power motor drives a horse clipper. The cream separator in the dairy house is operated by a one horse-power motor. In the residence a refrigerating p'ant is driven by a five horse-power Westinghouse motor, while a small duplex plunger pump for elevating rain water from a cistern to a pressure tank on the roof, and a boot polisher and buffer are each operated by a one horse-power motor of same type as the others. This makes a total of twenty-two horse-power driving various farm and domestic machines.

Upon the top of a high range of hills back of Burlingame is situated the Chateau of Prince Andre Poniatowski, and surrounding it is his famous horse breeding and stock farm, which requires a great amount of



THE SUBSTATION AT LELAND STANFORD JUNIOR UNIVERSITY.

water. Two pumps are there operated by Stanley two-phase induction motors, which are about fifteen miles from the generators in Redwood City Station.

Several of the vegetable gardens lying about San Mateo City are irrigated by means of centrifugal pumps driven by two-phase motors, having capacities of either three or five horse-power each, and in the neighborhood of Redwood City several other motors of a capacity of 7½ horse-power have disp'aced steam pumps and distillate engines in the fruit and vegetable ranches for irrigation.

Besides driving the pump for supplying the entire town of Redwood City with water, numerous motors of from one to five horse-power have been placed in commercial service for operating lathes and other machine tools, printing presses, soda works machinery and pumps for sa't works.

Just north from Palo Alto are situated a number of strawberry ranches which require thorough watering for about five or six months of the year, and prior to March, 1901, these centrifugal pumps were driven with distillate and crude oil engines. This class of prime movers has the disadvantage of getting out of order frequently, —generally just at a time when power is most needed. The "star" features of the electric motor are freedom

PUMPING STATION OF THE LELAND STANFORD JUNIOR UNIVERSITY.

from repair and attendance (especially with those of the induction polyphase type), reliability of service, ease of starting and cleanliness and noise'essness. At most of these ranches where electric power has been installed the motors are started and stopped by the resident women folks. One of the ranchers remarked a few weeks after the installation of his electric p'ant that he now had a "gentlemen's power." It was no longer necessary to don overalls on Sundays in order to pull over

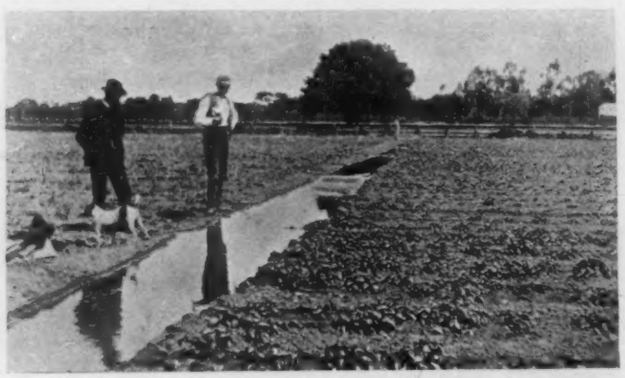
EXCAVATING FOR THE RESERVOIR FOR THE LELAND STANFORD JUNIOR UNIVERSITY.

the old distillate engine. Even with all the advantages and virtues of the electric power and figuring quite an item for repairs and depreciation against the explosive engine, the current must be sold at a very low figure per unit, even to very small power customers, in order

A TRANSFORMER HOUSE FOR 500-VOLT DISTRIBUTION.

to create a market for electricity in a country where these cheap and noisome powers have secured a footing.

As all central stations in large cities are desirous of securing a large and steady day output as well as a night load, there is no reason why, when installing electric plants situated in towns surrounded by agricultural districts of any importance, that the generators should not be of a type to facilitate their use for both light and power. Even though it were not possible to obtain a steady day load throughout the year, one could be secured during five or six of the spring and summer months and intermittent power during autumn. This



"ELECTRIC" IRRIGATION ON M. L. PITTMAN'S STRAWBERRY RANCH.

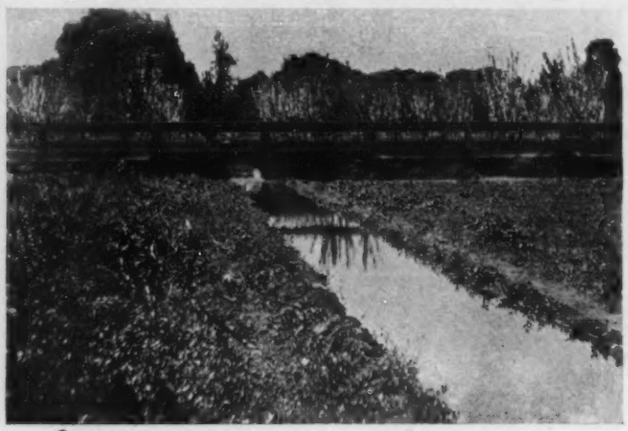
power is in nearly all cases utilized for raising water and it could be off before the lighting load would come on. Especially is this true in summer.*

The fixed charges against such a plant, i. e., interest, attendance, etc., remain almost the same, barring interest on power lines, whether the plant is operated during the day or not. In a case of this kind, the only additional charge would be on the power lines (where it was necessary to erect special lines), coal and water.

*The foregoing would of course only apply to a plant which operates an all-night lighting service, making it necessary to employ two watches or shifts.—C. H. P.

When the Consolidated Light & Power Company assumed control of its present plants, there was not an electric motor in its territory. At the present time a 150 kilowatt generator is fully loaded between the hours of 6 a. m. and 5:00 p. m., and the demand for power is steadily increasing,—all having been acquired within six months.

The total number of 16 c. p. lamps connected at the first named time was about 6000. Counting motors, arc and incandescent lamps there are at the present time,

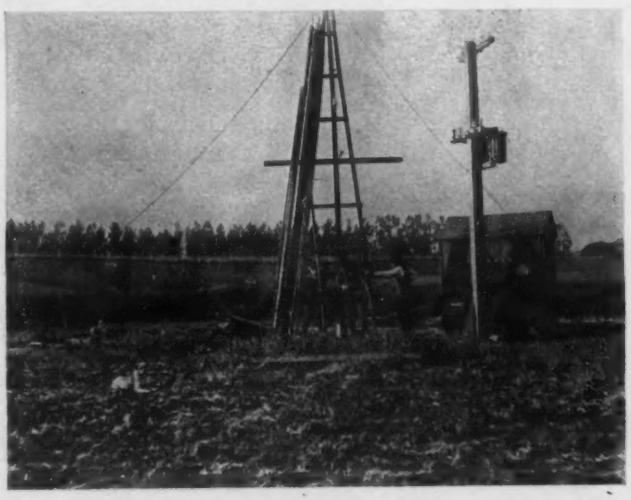


IRRIGATING FOR ORCHARD AND STRAWBERRY RANCH NEAR PALO ALTO.

the equivalent of 19,000-16 c. p. lamps connected to the lines, or an increase in connected load of over 200 per cent.

By consulting the folder map, herewith, an idea of the extent of the territory covered by the distribution lines of this company will be obtained. The total length of the district covered is over thirty miles, and it includes fourteen towns and small villages having railroad stations.

It is estimated that within the territory covered by the circuits of the Consolidated Light & Power Company there are now in operation engines developing



PREPARING TO IRRIGATE A SAN MATEO VEGETABLE GARDEN.

Supplement to the April, 1901, number of

The Journal of
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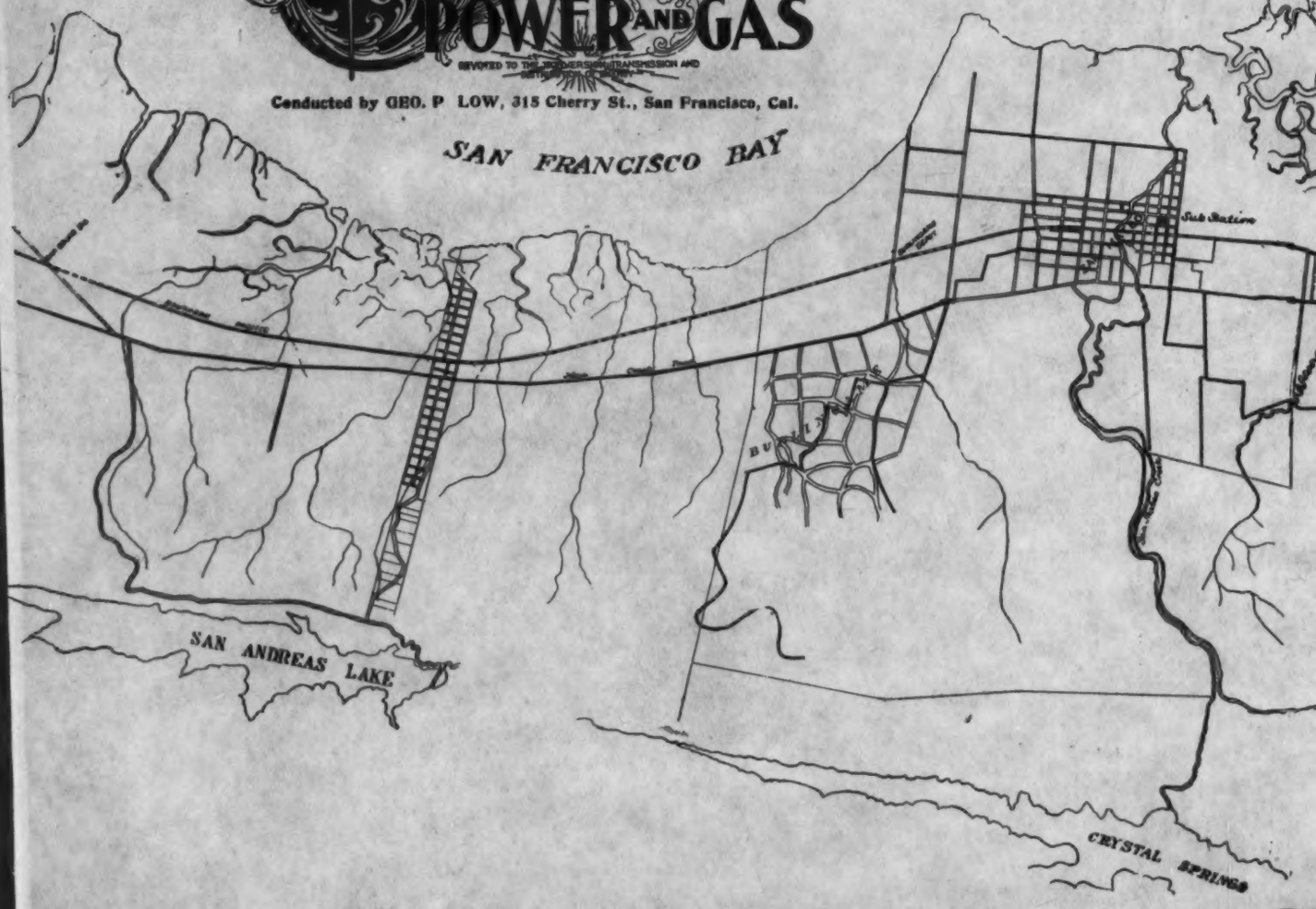
DEVOTED TO THE GENERATION, TRANSMISSION AND DISTRIBUTION OF ENERGY

Conducted by GEO. P LOW, 315 Cherry St., San Francisco, Cal.



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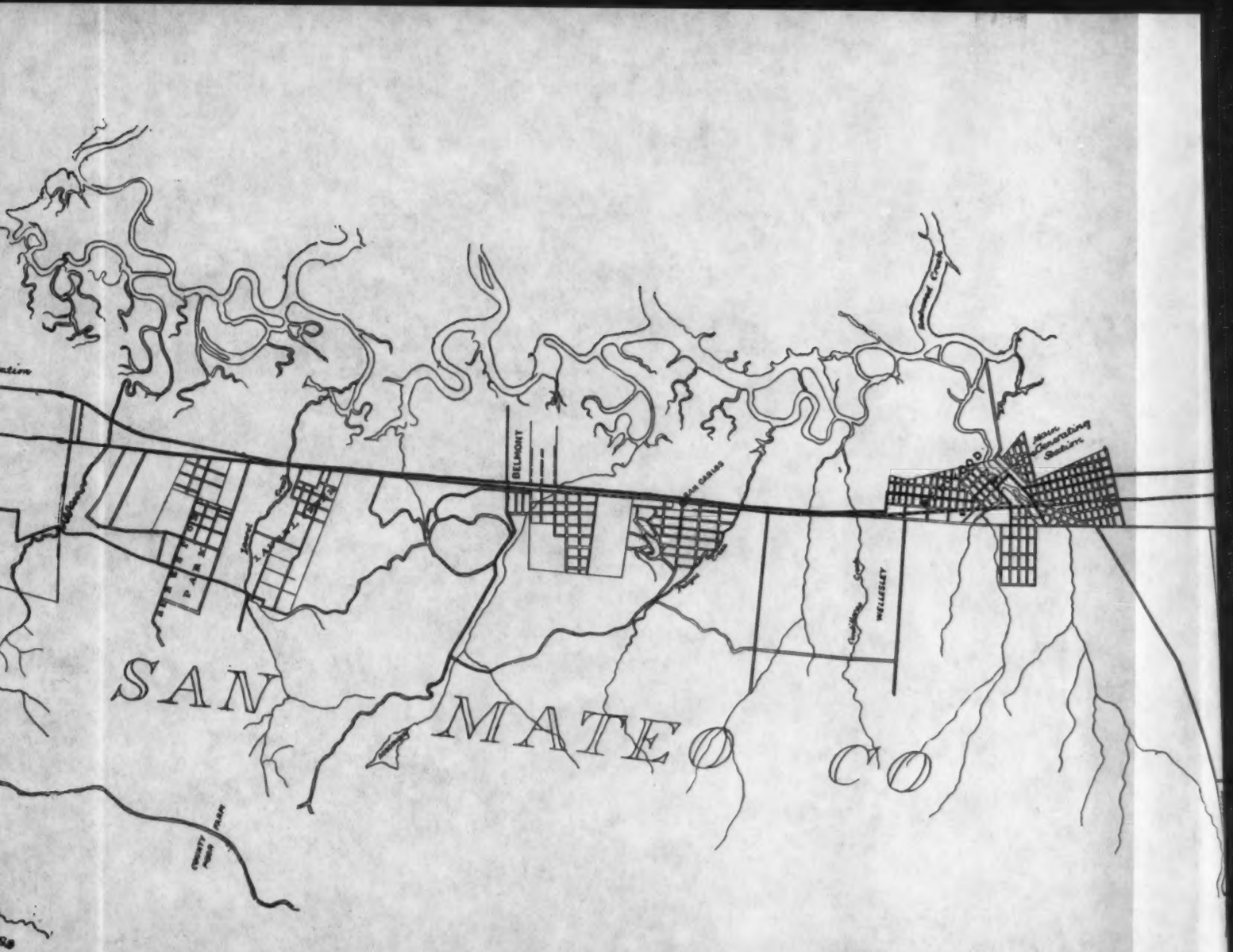
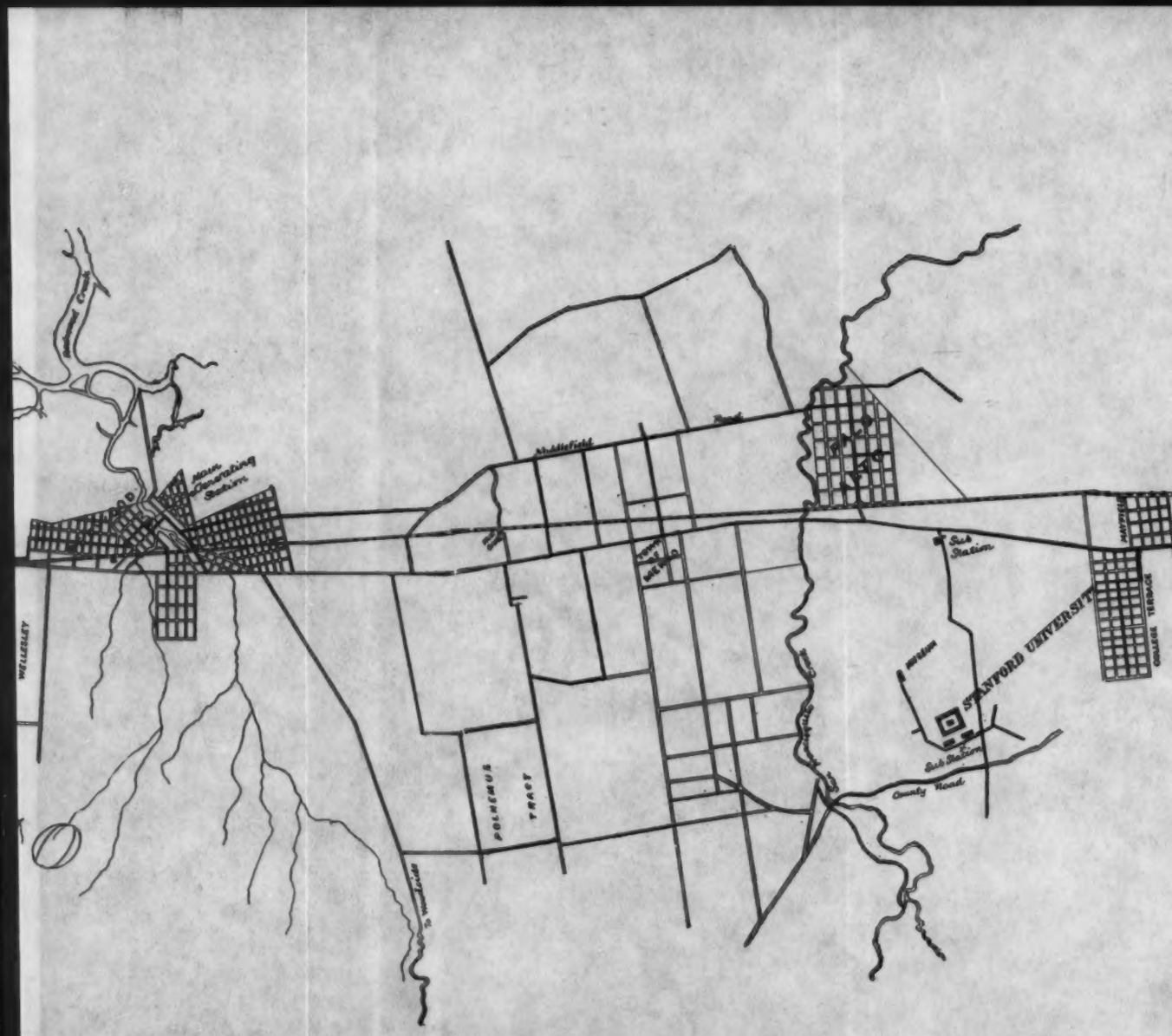


Distribution System of the Consolidated Light and Power Company,



and Power Company, of San Mateo County, California

Murphy
Dixie
MOUNTAIN VIEW
Charleston Road
COLLEGE TERRACE
SANTA CLARA CO

about 3,000 horse-power, and as the average cost of fuel producing this power is equivalent to coal at $10 per ton, it will be readily seen that the future opportunities of the Company are very great. In the district in and about Mountain View, there are hundreds and hundreds of acres of fruit orchards, all of which require irrigation.

The municipal plant at Palo Alto at present provides a midnight service, and negotiations are under way looking to the purchase of all night and day current by the municipality from the Consolidated Light & Power Company, in which event the town plant will be no longer operated.

The delivery of current by the Standard Electric Company, of California, is expected in the main station at Redwood City by June first next. The generating plants of the Company will then be shut down and used only as a reserve in the event of interruption in the service of the Standard Company.

The following are among the principal stockholders of the Consolidated Light & Power Company:

Wm. H. Crocker, H. T. Scott, Chas. G. Lathrop, Jno. J. Mahony, J. M. O'Brien, C. E. Green, R. J. Davis, Edward Pollitz & Co., A. F. Morrison, W. Frank Pierce, T. S. Bullock, Henry Kohler, C. E. Dugan, N. T. Smith, C. R. Splivalo, J. E. Green, Geo. C. Ross, W. A. Emmett, W. B. Cope, G. W. Kline, P. M. Roedel, Hermann Schainwald, Hugo Keil, Hugh Keenan, Chas. C. Moore, Thos. M. O'Connor, Geo. L. Payne, Clement Dixon, Laura B. Roe, Wm. Angus, Princess Ponitowski, C. O. Poole, C. H. Pennoyer.

Operation

A 750-KILOWATT HIGH-TENSION RHEOSTAT.

BY C. W. HUTTON.

RECENTLY the installation of a new water wheel governor at the Folsom powerhouse of the Sacramento Electric, Gas, and Railway Company, made it necessary to devise a rheostat to absorb 750 kilowatts of artificial load, testing the regulating qualities of the governor. The expense and trouble of building any of the ordinary forms of rheostats that had come to my notice, led me to try a very simple and inexpensive device with the following results:

A light wooden frame of 2x4 inch material in the form of an equilateral triangle was constructed, which measured 5½ feet on each side. Six ordinary oak pins, screwed into common double petticoat cable glass insulators, were let into suitable holes, two being bored into each corner of the triangular frame about six inches apart. Three pieces of No. 1 B. & S. bare copper wire, about 7½ feet long, one for each corner, were tied into the top grooves of the insulators, and the ends bent down, so that about 6½ feet of each wire was perpendicular to the plane of the wooden frame, making the terminal wires each 6 feet apart. A temporary frame over the forebay, a pulley, some rope and a signal gong on the forebay, which could be operated at the switchboard, completed the contrivance.

Measurements had previously been made by immersing two copper rods in the water and measuring the resistance with a bridge, to determine the depth of immersion and distance between rods necessary for the proper resistance. It was from this data, and not by experiment, therefore, that the contrivance was built. The distance between terminals had very little effect, and was arbitrarily taken at 6 feet. The resistance, as would be expected, varied inversely with the depth of immersion, and at 5½ feet, it was found to be 500 ohms, the required resistance between terminals to absorb 750 kilowatts of three-phase power at 11,200 volts.

The potential of the generator, which is 800 volts, was therefore stepped up through a set of transformers, to 11,200 volts, and three No. 10 B. & S. wires were strung from the transformers, up to the forebay and connected to the rheostat, sufficient slack being left in the last span to allow the rheostat frame to be raised and lowered. As the level of the water in the forebay was constantly varying on account of the variation of the regular load, which was being handled by the other generators, it was found very convenient to attach a 6 foot graduated wooden strip to one of the terminals so that the depth of immersion could be watched and kept constant or varied for any load desired.

This rheostat worked perfectly, and, as the water in the forebay was constantly running, an absolutely steady load could be had indefinitely.

THE STATIC PRESSURE OF WATER.*

A VERY convenient table, showing the static head or standing pressure of columns of water of various heights—and in fact for any height or head—may be compiled from the simple statement that the pressure exerted by a column of water one foot high is 0.434 pounds per square inch at a temperature of 62 degrees F. It is obvious that this pressure increases directly with the height of the column, hence a table showing the pressure of water in pounds per square inch for every foot in height to one hundred feet, and then by suitable intervals to five hundred feet, will enable the speedy derivation of the pounds pressure per square inch and the feet-head, or vice versa, for any condition of head or pressure.

Below is given such a table.

Feet head	Pressure per sq. inch	Feet head	Pressure per sq. inch	Feet head	Pressure per sq. inch	Feet head	Pressure per sq. inch
1	0.43	30	12.99	59	25.55	88	38.12
2	0.86	31	13.42	60	25.99	89	28.55
3	1.30	32	13.86	61	26.42	90	38.98
4	1.73	33	14.29	62	26.85	91	39.42
5	2.16	34	14.72	63	27.29	92	39.85
6	2.59	35	15.16	64	27.72	93	40.28
7	3.03	36	15.59	65	28.15	94	40.72
8	3.46	37	16.02	66	28.58	95	41.15
9	3.89	38	16.45	67	29.02	96	41.58
10	4.33	39	16.89	68	29.45	97	42.01
11	4.76	40	17.32	69	29.88	98	42.45
12	5.20	41	17.75	70	30.32	99	42.88
13	5.63	42	18.19	71	30.75	100	43.31
14	6.06	43	18.62	72	31.18	110	47.64
15	6.49	44	19.05	73	31.62	120	51.98
16	6.93	45	19.49	74	32.05	130	56.31
17	7.36	46	19.92	75	32.48	140	60.64
18	7.79	47	20.35	76	32.92	150	64.97
19	8.22	48	20.79	77	33.35	160	69.31
20	8.66	49	21.22	78	33.78	170	73.64
21	9.09	50	21.65	79	34.21	180	77.97
22	9.53	51	22.09	80	34.65	190	82.30
23	9.96	52	22.52	81	35.08	200	86.63
24	10.39	53	22.95	82	35.52	225	97.46
25	10.82	54	23 39	83	35.95	250	108.29
26	11.26	55	23.82	84	36.39	275	119.12
27	11.69	56	24.26	85	36.82	300	129.95
28	12.12	57	24.69	86	37.25	400	173.27
29	12.55	58	25.12	87	37.68	500	216.58

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EDITORIAL.

DAY LOADS FOR SMALL PLANTS.

Scattered through the country are numerous small electric generating stations that are being operated during but a few hours each day for the purpose of delivering the commodity of electricity in only one of its many marketable forms—namely, electric lighting. The Consolidated Light and Power Company of Redwood City, Cal., which forms the subject of the leading article of this issue, may, through its predecessors, be regarded as having been one of those low-load factor plants up to a year ago, when a change in management brought about new ideas and new policies that have wrought astounding changes to the lasting financial betterment of the concern. More than this, the system must stand as a monument of progressiveness, and as such its methods may well form an instructive study for the managers of those innumerable small electric lighting plants who fail to grasp the fact that the introduction of every new application of electricity into his business, brings a plant a step nearer to the ideal point of continuous full-load operation. And this alone is the position that, when attained, can give a plant its greatest earning capacity. One way that bids fair to achieve this is pointed out in the leading article referred to; other methods will perforce be evolved in analyses of the specific cases presented, but underlying will be found truths that are all-prevailing.

The lighting period of each day, if an all-night service be given, lasts over an average of about twelve hours; the maximum load or demand lasts only about two hours in most stations of this calibre, while the peak may be only of a few minutes duration. Despite this there must be apparatus installed of sufficient capacity to take care of the maximum requirements of the service.

As a rule the electrical machinery purchased for a plant of this description is of such a character as to tend to confine its use mainly to the supply of current for lighting. This is fallacious, as will be shown.

The interest on the investment and other fixed charges remain about constant through the twenty-four hours whether the plant is in operation or not, but the returns on the investment in a lighting plant are really earned during the two or three hours of heaviest load each night.

After-midnight there is no profit in running, but the plant must be operated in order to give a satisfactory service. Where a midnight schedule is not adhered to coal oil or some other illuminant must be kept handy to supplement the electric light after shutting down. This gets consumers in very bad ways; because if they are compelled to keep this substitute handy they will, at times, especially during cold weather, use it to the exclusion of the more modern commodity found in the electric lamp.

Why not then, realizing that the satisfactory results are obtained for only such a short period, cast about for means of keeping the apparatus occupied for a greater length of time with a profitable load. This can not be done during the hours of darkness because consumers can not be made to use much more light. They are now using all they require or can afford to pay for. The reduction of rates might increase the consumption, without, however, increasing the supply companies' receipts, and with the very bad result of causing an increased investment for additional machinery to handle the increased demand, as this additional load would in all probability come at the most undesirable time from a central station stand point, that is, during the peak. This condition, of course, prevails in plants of the type under discussion, but does not apply to those in the large cities where by low rates a great amount of advertising by electric signs and brilliantly illuminated stores is made possible.

In order to increase the revenue without additional investment for station equipment current must be disposed of in the daytime, when the machinery would be otherwise idle. If single-phase generators have been installed it will be useless to attempt motor power business on a scale which would prove profitable owing to the present state of the single-phase motor for anything but small powers. If poly-phase apparatus is installed there is a great field which can be opened up in an agricultural country or among suburban residents, especially the latter, where the water supply is inadequate or where the water rate is such as to compel the installation of private pumping plants. On the farm the uses to which the electric motor can be applied are legion.

In the town in which the plant is located a number of uses can be found for electric power and applied at a profit to the company.

It would be well for owners or engineers installing new plants or managers who are laboring under difficulties in attempting to rehabilitate old ones, to make a thorough investigation or canvass of the districts surrounding

a town in which a plant is to be installed or remodeled, to ascertain whether it would not be wise to install apparatus that could be used to advantage to handle a day business that might be added by an additional daily expenditure for coal only, the fixed charges being already taken care of by the night service.

CONCERNING ELECTRICAL STANDARDS.

The recent passage by Congress of a bill authorizing the establishment of a National Bureau of Standards, marks one of the most important and far-reaching steps ever taken by this country for scientific and industrial advancement. The technical press of the United States has repeatedly urged the creation of such a bureau, and it is gratifying to note that its efforts have been successful. tion of such a bureau, and it is gratifying to note that its efforts have been successful.

While the bureau will be of general benefit, the most pressing need for its services at the present time arises principally from the electrical field for the standardization of the ohm. There are four standards for the latter in existence to-day, namely, the "legal" ohm, the "international" ohm,the "British Association" or "B.A.." ohm, and the "Siemen's" ohm. The "legal" ohm was adopted by the International Congress of Electrical Engineers held in Paris in the year 1884. As adopted, the "legal" ohm was made equal to the resistance offered to flow of electricity (unit flow under unit pressure) by a column of mercury one square millimeter (0.03937 inch, or a small fraction less than 1-25 inch) in section and 106 centimeters (0.4173 x inch) in length, the temperature being at the freezing point (32 degrees F. or 0 degrees C.) and the pressure of the air being equal to the pressure at the base of a column of mercury 760 millimeters (30 inches) in height. The "international" ohm was adopted by the International Congress of Electrical Engineers, held during the World's Fair at Chicago in the year 1893. The unit adopted was the same in every respect as the "legal" ohm, except that the length of the mercury column was changed to 106.3 centimeters (0.4185 x inch). The "British Association" or "B. A." ohm was determined at London in the year 1863, by a committee appointed by the Association upon the same basis as that upon which the "legal" ohm was afterwards calculated or determined, i. e., upon what is called the C. G. S. (Centimeter-Gramme-Second) system—in fact, the Paris unit is really a correction of the "B. A." unit. The latter is smaller than the "legal" ohm, the actual proportion being 0.986 to 1.0. The "Siemen's" ohm is equal to the resistance offered to flow of electricity (unit flow under unit pressure) by a column of mercury 100 centimeters (0.3937 inch) long, the other details as to size, temperature and pressure being the same as those used in determining the "legal" ohm. Prior to 1884, electrical measurements in England and in a few other countries were based upon the "B. A." ohm, while those throughout Europe were based upon the "Siemen's" ohm. Since that time, however, both to a great extent have been replaced by the "legal" ohm, and the latter is the unit now most universally used, although the "B. A." ohm still finds favor in England in the measurement of the telegraphic apparatus. Since its adoption in 1893 little use has been made of the "international" ohm.

It would therefore seem, from the foregoing, that the Bureau will give greatest satisfaction to all concerned by adopting the "legal" ohm as the standard unit of resistance.

The present standards for the volt and the ampere are now as nearly correct, physically, as it is possible to determine them under the present state of the art, and it is likely that the Bureau will standarize them as they now exist. The standard volt, as now determined, is equal to a little less than the electro motive force of a Daniell cell (about 1.07 volts constant potential at 15 degrees) and is equal to 100,000,000 absolute or C. G. S. units of potential. The standard ampere as adopted by the Chicago Congress of Electrical Engineers was made equal to that "unvarying current which, when passed through a solution of nitrate of silver, in water, deposits silver at the rate of 0.001118 grams per second." It is equal to one-tenth of an absolute or C. G. S unit of current strength. It will therefore be seen that the ohm is equal to 1,000,000,000 absolute units of resistance.

With invariable standards for the volt, the ampere and the ohm, the determination of other standards will be greatly facilitated.

One of the most urgent and important needs of the electrical industry to-day is a standard candle-power. There are several standards for the unit of light extant, only one or two of which, however, approach anywhere near fulfilling the requirements of a standard flame. A candle-power, as known in this country and in England, is assumed to be the light produced by a standard candle weighing six to the pound and burning 120 grains of spermaceti wax per hour, the length of the candle measured from the shoulder, ranging from 8¼ to 9 inches, and the diameter from 0.8 inch at the shoulder to 0.85 or 0.9 inch at the bottom. In Germany, a standard paraffine candle is employed, but no better results are attained with it than with the sperm candle. In France, the official standard is the "Carcel" lamp, in which purified colza oil is consumed at the rate of 42 grammes per hour. It is computed to be equal to about 9.5 standard spermaceti candles.

What are known as the Methven "screen" and the Harcourt "air-gas" or "pentane" standard fulfill more nearly the requirements of a standard flame. The former "consists of an upright rectangular metallic plate or screen, having attached to its lower edge a horizontal flange or bracket, which supports a standard London Argand burner. The latter is supplied with gas (common coal, etc.) through a plug or nosepiece projecting

downwards below the flange. In the screen, above the level of the burner, there is a hole or slot which is covered by a thin silver plate, having a small vertical slot of such dimensions as to allow of the passage of just as much light as equals that afforded by two average standard sperm candles when the gas consumed is sufficient to yield a flame three inches in height. In the Harcourt standard the combustible employed is a mixture of one cubic foot of air to three cubic inches of pentane, measuring the liquid at or near 60 degrees Fahrenheit, or measuring both as gases, 20 volumes of air to 7 of pentane. The burner used has an opening 1-4 inch in diameter at the top of a cylindrical tube 1-4 inch in diameter and four inches long, the thickness of the disc forming the mouthpiece at the top of the tube being 1-2 an inch. With a burner of these dimensions the mixture of air and pentane gas yields as nearly as possible a flame 2 1-2 inches in height when the rate of consumption is 0.5 cubic foot per hour. Tests show that a flame of this heighth produces a light equal to that produced by one hundred standard sperm candles.

While the Harcourt standard is slightly more accurate than the Methven, it is less convenient in many respects, and is for that reason rarely adopted in practice. The Methven "screen," on the contrary, is now almost exclusively used as the standard in rating the candle-power of incandescent and arc lamps. In the whole matter of candle-power the difficulty lies not only in obtaining a standard unit of luminosity, but also in obtaining a means of accurately measuring the same for comparison with other sources of light.

From the foregoing it will be seen that the National Bureau of Standards has much to accomplish, and the scientific and industrial interests of the country therefore demand that it be in operation at the earliest possible moment.

GROWTH OF THE NIAGARA PLANT.

Probably no long-distance transmission line in the world has dependent upon it such important commercial interests as that which carries Niagara power to the city of Buffalo, and no line in the world is a better illustration of the practicability of transmitting large amounts of power by electrical means over long-distance lines. Every trolley car in Buffalo receives its power supply over this line, and every arc lamp, as well, in the streets of Buffalo, and many of the important factories of that city have no other source of power for their operation than electric power from Niagara Falls.

Such has been the fulfilment of the prophecy made not many years ago that, to transmit Niagara power for a distance of more than two or three miles from the Falls, would be "commercially impractical!" Already it has reached out, in the case of some of the arc lamps, on the outskirts of Buffalo, to a distance of nearly 40 miles.

On account of the great importance of the Buffalo transmission line, it had to be constructed with the utmost care in order to avoid interruptions in service from mechanical defects, and had to be insulated in such a way as to be absolutely unaffected by any of the stresses of weather to which it might be subjected

The current issue of an American engineering magazine contains an excellent article* which glances at the past development of the Niagara Falls Power Company and indicates the lines along which it is likely to grow in the future. As the manufacturing arts advance, the element of power becomes more and more important and cheap power, therefore more demanded. Electro-chemistry is a new art, and one which has great possibilities ahead of it. The high temepratures obtainable in electric furnaces have opened up a new field to chemical synthesis, and it is likely that many as yet undiscovered processes, which will require large amounts of electrical power for their operation, will be brought to light. The supply of power for electro-chemical purposes is especially desirable in a water power plant where large investment is necessary, for the power used by these processes is practically constant for twenty-four hours of the day, thus tending to reduce load "peaks" on the total station output.

The economical distance to which power can be transmitted extends every year as the general demand for power increases and methods of handling high voltages improve, and the electric equipment of steam railway systems, which is certain to come in time, will open up a further field for the long-distance transmission of large amounts of power from a central point.

A second Niagara power house is at present in the couse of construction by the Niagara Falls Power Company. This is located near the present one, on the opposite side of the inlet canal, and will be essentially a duplicate of it. It is expected that this will start into operation by the end of the present year. This new power house, when complete, will contain eleven 5000 horse-power generators, which, together with the present plant, will make a total capacity of 105,000 electrical horse-power.

ELECTRICITY IN MUSIC.

The following item was clipped from *Music Trades* of February 16, 1901. It appeared on the page devoted to improvements in instruments and notices of new inventions in the music line:

HE INVENTED A TROLLEY HARP.

(Special to *Music Trades.*)

PITTSFIELD, MASS., February 11, 1901.—Henry Heno, a motorman on the street railroad here, has been granted a patent on a trolley harp. H. G. Avery, of Albany, N. Y., is manufacturing a dozen of these harps for Mr. Heno, and a company is being talked of to make them in Pittsfield. A number of street railway companies in various parts of the country have made inquiries regarding the invention.

Verily the enterprise of some special correspondents is past the average understanding! Perhaps this one imagined a trolley harp is used only on special occasions; trolley parties, for example? We give it up.

*H. W. Buck in *Cassier's Magazine*, Vol. XX, No. 1.

Pneumatics

COMPRESSED AIR IN MINING TRANSMISSION.*

BY J. H. RONALDSON.

THE transmission of power, to a greater or less distance, is frequently a subject for the serious consideration of a mining engineer, and thanks to the advances in scientific and mechanical knowledge made during recent years, the choice of method is varied and the possible efficiency is considerable. The means of transmitting power are steam, water, wire rope, electricity and compressed air, and the advantages and disadvantages of each of these systems vary with the distance to be bridged and the conditions attending their application.

Within moderate distances and under certain conditions, steam is at once the most economical and satisfactory means of transmitting power, but the limitations to its use are too familiar to require enumeration.

There is no more valuable agent than water for actuating hoists and for certain pumping operations in mines, where excessive lifts over long distances have to be overcome.

For the general purposes of haulage, wire rope transmission of power is unexcelled, and has in many instances been used for other purposes, such as pumping in mines. For the latter purpose it has, however, received a limited application, a result due, it is to be feared, to defective installation, through a frequent ignorance of the properties of ropes and pulleys. When one remembers the admirable work done in the way of haulage, pure and simple, by modern ropes, it is inconceivable to think that this method could not be applied to pumping in mines, in many instances with favorable results. As an example it may be mentioned incidentally that at the Metropolitan Colliery in New South Wales, a band rope of crucible steel 1¼ inches diameter, taken down a shaft 1,100 feet deep, and transmitting at least 100-horse power regularly for ten hours per day, worked without change for five years and was then only taken off to insure perfect safety in an important service. The rope was far from being worn out when changed.

As a competitor with compressed air, electricity occupies the first place. Its use as a means of transmitting power has of recent years been widely extended, and in mines we have it now applied to pumping, haulage, per locomotives, and fixed rope haulage engines actuated by electricity, winding above and below ground, to rotary and percussive drilling, and most successfully to coal cutting machinery.

For the transmission of power this agent has, therefore, in certain directions serious competitors, in favor of which there has frequently been urged greater economy in first cost, in working cost, in efficiency and in applicability. These claims have, however, been keenly contested by the advocates of compressed air who, on the other hand, contend that it supplies a means of power transmission at once safe, economical and efficient for general mining work. The force of this contention has been much increased by the improvements effected during the last twenty-five years, in the methods of compressing air and of using it, as will be shown later on. There is little need to dwell on the importance of compressed air as a factor in the economy of many mines, an enumeration of its uses making this sufficiently apparent. It is used to actuate rock drills, underground haulage and hoisting engines, pumps, underground ventilating fans, air injectors, and coal cutting machines.

It is necessary to an intelligent appreciation of the subject to consider the laws relating to air as a gas, and the mechanical causes which render its economical use more difficult than would at first sight appear. It is proposed, therefore, to consider the subject in the following order: (I) The laws affecting the compression of air; (II) the various styles of compressors; (III) the causes of low efficiency in air compressors; (IV) air conduits; (V) methods of using compressed air; (VI) dangers attending its use.

*A paper read before the New South Wales Chamber of Mines, June, 1900.

I.—LAWS AFFECTING COMPRESSION.

Air is an elastic fluid which, when free from vapor, behaves as a perfect gas; 13.09 cubic feet at ordinary atmospheric pressure, and at 60 degrees Fahrenheit, weighs 1 pound. According to Boyle's law, the volume of a gas varies inversely as the pressure affecting it so long as the temperature remains constant; consequently in doubling or trebling the pressure the volume becomes one-half or one-third respectively. According to Charles' law, if the volume of a gas be kept constant, the pressure varies as the absolute temperature, and if the pressure be kept constant the volume varies as the absolute temperature. By the law of the transmutation of energy, work performed on a body, whether solid, liquid or gaseous, is evidenced by a definite increase of temperature in that body, and we are familiar with that fact as shown in the simple laboratory experiment of exploding a small charge of guncotton in a strong glass cylinder through the rapid heating of the air contained in it by a sudden jerk of a tightly fitting piston. Consequently when air is compressed it is heated; when heated it expands, and the volume of air to be compressed is proportionately increased with a corresponding expenditure of the power required to compress it. Could the temperature of the air undergoing compression be kept constant (isothermal) during the process, and the heat taken up from it returned to the air during its expansion in the motor while doing work, all loss from this source would be avoided. This, however, is impossible, and the aim of modern compressors is to prevent an increase in the volume of the air by keeping down the temperature during the period of compression; that is, by approximating to what is termed the isothermal process. It is clear that the least efficient compressor is the one in which no provision is made for cooling the air during the actual period of compression, that is one working on what is termed the adiabatic process.

II.—AIR COMPRESSORS.

Although compressed air had been used to a small extent previously, it was not until 1850, when the Mont Cenis tunnel was constructed, that its use became general. Two forms of compressors are in use, in each of which a reduction of the temperature of the air is aimed at; in one case by the use of a liquid piston in the cylinder, and in the other by a water-jacket round the cylinder, or by an internal spray of water. The former is termed a "wet" and the latter a "dry" compressor.

Of wet compressors, there are two types: (a) where the water piston owes its energy to the fall of water from a height; (b) where the water piston is actuated by a steam driven piston. At Mont Cenis, Mons. Sommeiller made use of water with a fall of 86 feet, and by utilizing the momentum of the falling water he was able to obtain an air pressure of 75 pounds per square inch. Though extremely low in efficiency (not more than 6 per cent.) and necessitating clumsy plant, the arrangement gave results sufficiently good. This principle has been applied in other cases, and one arranged by Hathorn, Davey & Co., Leeds, was successfully used for many years in Mexico. The application of the principle is simple, and where an abundant water supply exists, excellent results are obtained. The second form of wet compressor has attained a wide application on the continent of Europe, where, particularly among the highly educated Belgian and French engineers, the principles of air compression are more thoroughly understood than in Britain. It is, however, a question if their adherence to this method is not an instance of the length to which a desire to reach an ideal perfection may lead one from the best practical solution of a problem. As will be shown later on, the dead space at the end of the air piston stroke is undesirable, and it was largely to eliminate this defect and to keep the air cool that liquid pistons had such a vogue on the Continent. The water forced back and

forward in the cylinder and up the pipe at each end, carrying the necessary valves, filled the dead space. But unfortunately for this ideal, there are a number of inconveniences attendant on the system. The cooling of the air is insufficient because it is only on the surface of the water. The speed of the piston is extremely limited and cannot exceed forty to fifty feet per minute, on account of the mass of water to be moved; consequently the number of compressors required for a given work is large. The water agitated by the motion is frothed, and causes an excessive moisture in the air. Various devices more or less successful have been used to lessen these defects, but, in spite of all, the fact remains that in other countries these compressors have not found favor.

The dry compressor has a cylinder and piston similar to those of a steam engine, with suitable outlet and inlet valves at the cylinder ends. The temperature of the air is kept within reasonable limits by the constant flow of cold water through the water jacket of the cylinder from the bottom upward. It is, however, doubtful if this process of cooling, even under the most favorable conditions, does more than keep the cylinder from becoming excessively heated and so imparting heat to the incoming air. A more thorough method of cooling is obtained by injecting a fine spray of cold water into the cylinder near the outlet valves. To this the objection has been strongly urged that the presence of water with its non-lubricating properties causes an undue wear and tear in the cylinder and loss in power.

III.—CAUSES OF LOW EFFICIENCY.

The causes of low efficiency in air compressors, briefly stated, are the heating of the air during compression, mechanical defects in the inlet and outlet valves, and leakage past the piston. It has been already shown that air when subjected to compression is heated, and that, as the volume is thereby increased, much power is uselessly expended in dealing with the heated air. The most efficient compressor, therefore, in this regard, must be the one presenting the best cooling arrangement for the air as it is being compressed. That form of compressor in which the piston is represented by the falling water supplying the power, such as Sommeiller's, permits of a very thorough cooling, as the water piston is renewed each stroke.

But in the second form of wet compressor, such as Dubois' of Mariehaye Colliery, Belgium, in which the water, only slightly renewed per stroke, becomes considerably heated, the cooling is not more perfectly effected than in the dry compressor. As the pressure to which the air is raised becomes greater, the losses from this source become serious, and as the efficiency of the motors increases with the pressure, and the size of the conduits can be correspondingly small, it is desirable, particularly in large installations, to use high-pressure air. The most satisfactory results in this direction have been obtained by stage compression—that is, by pressing the air to a certain pressure in one cylinder and further compressing it in a second, and, if desired, in a third, or even a fourth. By this system the air is cooled between each stage, and the losses from this source are minimized. For low pressures it is doubtful if any practical economy would result from stage compression, but it is now fully demonstrated that for pressure above 60 pounds the advantages of stage compression are very marked. To diminish losses caused by resistance to the passage of the air through the inlet and outlet valves many devices have been resorted to. In the ordinary valves held to their work by springs the valves rattle or chatter if the springs are weak. On the other hand, if the springs are made very strong, a resistance to the passage of the air is set up, resulting in a loss of power which in some cases becomes serious. To obviate this defect the valves are occasionally devised to open mechanically. In a short paper such as this it is impossible to enter into the details of the various valves used. It is not uncommon to hear much stress laid on the losses caused by the unavoidable dead space occupied by compressed air at the end of each stroke, and it may be pointed out at once that the loss is not in power, but solely in the volumetric capacity of the compressor. To diminish this inconvenience, the air piston is usually run as close to the cylinder ends as practicable, and care is requisite to avoid sailing too close to the wind in this direction and damaging the mechanism. The best plan is to arrange trick passages or grooves on the inside of the cylinder, for a short distance back from each end, to allow the air in the dead space to pass the piston to the end in which compression is about to begin. The inside pressure against the suction valves is thereby relieved, and compression on the other side of the piston begins at once. To prevent knocking, through the sudden relief caused thereby at the end of the stroke, a certain amount of cushioning in the steam cylinder is required. The low efficiency, due to leakage of the pistons, can only be effectually reduced by carefully attending to their condition.

IV.—AIR CONDUITS.

Two considerations are of importance in determining the pipes to be employed; these are the size of the pipes and the character of the joints. The frictional loss in the passage of the air through the pipes increases very rapidly as the diameter decreases, as shown by the following example. If a volume of air at 60 pounds pressure, equivalent to 18,000 cubic feet per hour at atmospheric pressure, be passed through 1,000 feet of pipes the loss of pressure of air for 2½ inch, 3 inch, 3½ inch and 4 inch pipes would be 5¾ pounds, 2 pounds and 1½ pounds respectively. Leakage at the joints, through the expansion and contraction of the pipes, is a fruitful and at times a serious source of loss of power. A receiver of suitable size should always be placed alongside the compressor, and where a considerable length of pipes is used, it is an advantage to have a receiver as near the motor as practicable.

V.—METHOD OF USING.

When air is compressed it is heated, and when it expands it is cooled. The latter fact gives rise to the inconvenience so frequently met with in air motors, of ice being formed in the ports, through the freezing of the moisture in the air. Where the air is admitted to the motor practically during the whole stroke there is little danger of ice being formed,but there is a terrific waste of power, for it is as important for economy to use air expansively as it is to use steam expansively. While a little moisture in air used expansively results in the formation of ice in the ports, it may be pointed out that aqueous vapor has a specific heat nearly double that of air, and consequently cools less rapidly under expansion than dry air, and the tendency of an excess of moisture is to reduce the cooling. The specific heat of water being still greater, a spray of water may be effectively used in the motor cylinder to prevent cooling to the freezing point. The writer was familiar many years ago with an instance where, in the case of large haulage engines placed underground, the inconvenience caused by freezing was so serious that compressed air was abandoned, and steam, though inconvenient, was substituted. Reheating the air is, however, the most effective method of allowing air to be used expansively, without the formation of ice in the ports, and this can best be done by passing the air near the motor, through a coil of pipes heated by a small furnace; and a further elaboration, permitting the highest degree of expansion, is effected by introducing a small quantity of water into the heater, where it is converted into steam. A move in the latter direction was made years ago by the use of a jet of steam in the air pipe, near the motor. In practice it is found that reheating the air not only prevents freezing, but results in a very great economy in the use of compressed air at a small cost both for plant and fuel.

VI.—DANGERS ATTENDING ITS USE.

These are so slight as to be scarcely worth considering, but their existence is worthy of passing notice. A few cases are known where an exploson, more or less maked, has occurred

in the receiver placed near the compressor. In these instances combustion has been set up apparently in the carbonaceous matter, deposited from the lubricants used in the compressor. The readiness with which a piece of old oily waste takes fire at comparatively low temperature is well known, and it is possible that a similar action may take place in the deposited carbon, if subjected accidentally to abnormal heating by a failure in the cooling apparatus of the compressor.

The use of compressed air seems at first sight an extremely simple one, and consequently the principles surrounding its use are seldom inquired into. The results obtained from it are, in consequence, at times appallingly poor, and its reputation as a means of transmitting power suffer proportionately. In the worst forms of machines 10 per cent. only of the power expended may be obtained, and the writer has a distinct recollection of the care with which his Belgian professor demonstrated the impossibility of obtaining more than 33 per cent. of useful effect from compressed air. But to quote from Professor Goodman: "In the best cases, without reheating, about 55 per cent. and with reheating 75 per cent. of the total power is given out by the motor." The extensive use made of compressed air in metalliferous mines, particularly for rock drills, should naturally induce an intelligent interest in its use and a discriminaton in the proper and improper methods of employing it.

Mining

POLYPHASE MOTORS IN HOISTING DUTY.

THE publication of Mr. Gibson's communication in the last issue and the reference therein to the use of electricity in mining in the Transvaal, has brought out the following from an observing mining engineer who requests that if the letter be published, it shall be done anonymously:

The advantages possessed by incandescent electric lights for mine lighting are so well understood that any enlargement upon the point would be redundant. This, however, appears to be about the only qualification that has been voluntarily conceded to electricity from the outset, as all other applications have forced their way to recognition by virtue of their own merits. The fact is that in some forms of mining equipment electric power is pre-eminently superior to any other, be it water or steam, for the reasons that the motor automatically absorbs power from the power lines in exact ratio to work that it performs; the speed is practically constant at all times regardless of load and if the power supply is ample, the motor will deliver, for brief periods, several times its rated capacity for doing work. It occupies a minimum of space and requires a minimum of attention; it is ever ready for work and is capable of longer continuous runs than any other power-giving mechanism. For these reasons, if for no other, the electric motor, whether of the direct current of polyphase type, is better adapted for the driving of rock breakers, stamps, concentraters or any other mining appliance requiring a practically steady supply of power, than any other medium.

It is to be regretted that engineers who are having experience in the applications of electricity in mining deny themselves the blessings of unrestricted discussions of their observations, such, for instance as experiences with polyphase electric motors in the operation of mining hoists. This theme is one presenting a most difficult problem to the electrical engineer, for the reason that the application of polyphase motors is fast becoming universal in electric transmission plants, which renders it both economical and advisable that such motors should be used to the exclusion of direct current types. But polyphase motors are inherently so constituted that they work to best advantage when at full and unvarying speed and at practically unvarying loads. These conditions are the very antipodes of those existing in mine hoists, where the speed, the amount of and variation in load, vary to the widest possible degree. Nevertheless the trying conditions imposed are being slowly but surely overcome, and it is believed by many of high repute that the period is not far distant when the application of polyphase motors to every variety of mine hoist will be an accomplished success. The operation of hoists by direct current apparatus is in as high a state of perfection as is the electric street railway system. Electric pumping is in an equally satisfactory condition, but as stated, the development of polyphase motors for hoisting work, is more backward, though by no means may it be maintained that there has been no satisfactory progress in the way of its utilization in that direction.

Miscellany

TWENTY 3600-HORSEPOWER TRANSFORMERS.

THE rapidly increasing use of polyphase current in power plants of great size is creating a demand for transformers of a larger capacity than have ever before been designed. The Chambly Manufacturing Company has recently placed with the Westinghouse Electric and Manufacturing Company the largest single order for transformers ever recorded. This order comprises twenty 2,750 Kilowatts transformers of the Westinghouse air blast type. Each of these, with an output of over 3,600 horsepower of electrical energy, weighs approximately eleven tons and stands nine feet high. Of the twenty units, ten are used to raise the voltage from 2,200 to 25,000 volts at 8,000 alternations. The input is 2-phase and the output 3-phase. The remaining ten transformers, for lowering the voltage, receive the 3-phase line current at 22,000 volts and deliver out a 2-phase current at 2,400 or 4,800 volts as required. The blowers for furnishing the air blast for cooling both the raising and lowering transformers are operated by Westinghouse type C induction motors.

The well known Westinghouse methods of construction are employed in these transformers, both primary and secondary being divided into several flat coils wound with many layers, and few turns per layer, each coil being insulated separately. The advantages of this construction are that it divides the total E. M. F. between the several coils, reducing proportionately the strain of each individual coil, also, it divides the E. M. F. in a single coil between many layers, thus reducing the potential between the adjacent layers. The regulation of the transformers is also improved, and the windings may be connected easily in series or multiple, thus giving a wide range of E. M. F. Also, in case of damage to a coil a substitute may be provided with but little trouble, and without sending the transformer to the works.

Iron and copper have been carefully proportioned to secure the minimum losses, and the efficiency of the transformers is very high, being considerably over 98 per cent. It is, however, not sufficient that the loss in a transformer be low when it is first installed, for, as is now generally known, much of the iron that has been used in transformers when subjected to the conditions prevailing in continued service is subject to a material deterioration, more or less rapid, with the result of a corresponding material increase in the iron losses. In some cases this increase has amounted to a doubling of the loss found in the transformer when first installed. The Westinghouse engineers early discovered this characteristic and at once began a careful and systematic study of the subject, with the ultimate result that there was established a special and thorough process for the manufacture and treatment of transformer iron. Entire success was attained in producing an iron at once capable of high magnetization with comparatively little energy and having a stable character completely resisting the tendency to deteriorate in service and show increased losses.

A peculiar feature of these large transformers is the change effected in them from 2 to 3-phase and from 3 to 2-phase current, the change being secured by means of special windings, invented by C. F. Scott of the Westinghouse Company.

Transmission

THE NIAGARA-BUFFALO TRANSMISSION LINE.

THERE are three separate transmission circuits from the Niagara power house to Buffalo, two of which are copper, and installed on the same pole line. The third circuit is strung upon a separate pole throughout its entire length, and is of aluminum instead of copper. This aluminum line has the same resistance as each of the other two, and is composed of three cables of 500,000 circular mils each, made up of thirty-seven strands. At the present market price of copper wire it is cheaper to use aluminum for overhead lines where the conductors do not have to be insulated. The conductivity of aluminum is less than copper, and the price per pound is greater, but the volume per pound of aluminum is much greater than that of copper on account of the lower specific gravity of the metal. When, therefore, resistance per pound is taken as the basis for comparison, aluminum is found to be cheaper.

Some details of these lines have recently been given by H. W. Buck,* who states that since the long-distance service to Buffalo was started in 1896, the line has been operated at a potential of 11,000 volts; but recently the voltage has been raised to 22,000, and the capacity of the three Buffalo circuits is now 30,000 horse-power, with about 10 per cent line loss. No power is taken from the Buffalo transmission line until North Tonawanda is reached —a distance of about ten miles. The Tonawanda Power Company, which is the name of the organization distributing power in this district, is a sub-company of the Naigara Falls Power Company, and at present utilizes about 1000 horse-power.

At the point where the Buffalo transmission line is tapped with supply lines for the Tonawanda sub-station the transmission line which supplies the city of Lockport with electric power is also connected. This branch line, consequently, has the same voltage, phase, and frequency as the Buffalo line. Its length is about 15 miles, making the Lockport sub-stations about 25 miles from Niagara Falls. Three-hundred horse-power is used by the local electric lighting company in motor generator sets, and about 600 horse-power in a rotary converter sub-station which supplies power for local electric railroad service. It is from this sub-station that the 40-ton electric locomotives are operated which daily haul heavy freight trains on this feeder of the Erie Railroad, hauling at times as many as twenty-eight loaded freight cars. Since the sub-station feeds direct current for a distance of 10 miles beyond the sub-station, on certain sections of this route the locomotives receive their power at a distance of 35 miles from the Niagara power house. This is a forcible illustration of what can be accomplished by the application of electrical power to steam railroad service.

About 23 miles from the Niagara power house, just inside the city line of Buffalo, the overhead circuit of the Buffalo transmission line enters the terminal house of the Cataract Power and Conduit Company. This company, which also is a sub-company of the Niagara Falls Power Company, distributes Niagara power throughout the city of Buffalo; purchasing it from the Niagara Falls Power Company at the Buffalo City line, at which point the responsibility of the latter company nominally ceases. In the terminal house the 22,000-volt current is transformed by six of the largest transformers in the world, 3000 horse-power each, to three-phase, at a pressure of 10,000 volts, in which form it is distributed by underground cables to the various Buffalo sub-stations.

Edward P. Burch of Minneapolis has been appointed consulting engineer for the Everett (Wash.) Railway and Electric Company in the reorganizing and rebuilding of its electric lighting, electric railway and water pumping interests.

"THE JOURNAL shows great signs of promise."—*Electrical Review* (N. Y.).

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*Cassier's Magazine, Vol. XX, No. 1.

Transportation

FRANCHISES IN CALIFORNIA.

BELOW is given in full an act passed by the Legislature of California providing for the sale of street railway franchises in municipalities, and providing conditions for the granting of such franchise by legislative or other governing bodies, and repealing conflicting acts, which went into effect March 9:

An Act providing for the sale of any street railway and other franchises in municipalities, and providing conditions for the granting of such franchises by legislative or other governing bodies, and repealing conflicting acts.

The people of the State of California, represented in Senate and Assembly, do enact as follows:

Section 1. Every franchise or privilege to erect or lay telegraph or telephone wires, to construct or operate street railways upon any public street or highway, to lay gas pipes for the purpose of carrying gas for heat and power, to erect poles or wires for transmitting electric heat and power along or upon any public street or highway, or to exercise any other privilege whatever hereafter proposed to be granted by boards of supervisors, boards of trustees, or Common Councils, or other governing or legislative bodies of any city and county, city or town within this State, except steam railroads and except telegraph or telephone lines doing an interstate business, and renewals of franchises for piers, chutes or wharves, shall be granted upon the conditions in this acts provided, and not otherwise.

Sec. 2. An applicant for any franchise or privilege above mentioned shall file with the governing or legislative body of the municipality an application, and thereupon said governing body shall, in its discretion, and when the application is accompanied with a petition praying that the same be granted, signed by the owners of three-fourths of the frontage of the real property fronting along and upon the route of the franchise applied for must advertise the fact of said application, together with a statement that it is proposed to grant the same, in one or more newspapers of the city and county, city or town wherein the said franchise or privilege is to be exercised. Said advertisement must state that bids will be received for such franchise, and that it will be awarded to the highest bidder, and the same must be published in such newspaper once a day for ten successive days, if it be a daily newspaper, and if there be no daily paper published in such city and county, city or town, then it shall be published in a weekly newspaper once a week for four successive weeks, and in either case the full publication must be completed not less than twenty (20) nor more than thirty (30) days before any further action can be taken thereon.

Sec. 3. The publication must state the character of the franchise or privilege proposed to be granted, the term for which it is granted, and, if it be a street railway, the route to be traveled; that sealed bids therefor will be received up to a certain hour and day named therein, and that the successful bidder and his assigns must, during the life of said franchise, pay to the municipality 2 per cent of the gross annual receipts of the person, partnership or corporation to whom the franchise is awarded, arising from its use, operation or possession. No percentage shall be paid for the first five (5) years succeeding the date of the franchise, but thereafter such percentage shall be payable annually; and in the event said payment is not made, said franchise shall be forfeited; provided further, that if the franchise be a renewal of a right already in existence, the payment of said percentage of gross receipts shall begin at once.

Sec. 4. In case the franchise granted shall be an extension of an existing system of street railway, then the gross receipts shall be estimated to be one-half of the proportion of the total gross receipts of said system which the mileage of such extension bears to the total mileage of the whole system, and said

estimate shall be conclusive as to the amount of the gross receipts of said extension.

Sec. 5. Said advertisement shall also contain a statement that the said franchise will be granted to the person, firm or corporation who shall make the highest cash bid therefor; provided only that, at the time of the opening of said bids any responsible firm or corporation present, or represented, may bid for said franchise or privilege a sum not less than 10 per cent. above the highest sealed bid therefor, and said bid, so made, may be raised 10 per cent. by any responsible bidder present, and said franchise or privilege shall finally be struck off, sold and granted by said governing body to the highest bidder therefor, in gold coin of the United States, and said successful bidder shall be required to deposit with said governing body, or such person as it may direct, the full amount of his or its said bid, within twenty-four hours thereafter; and in case he or it shall fail so to do, then the said franchise or privilege shall be granted to the next highest bidder therefor.

Sec. 6. Work to erect or lay telegraph or telephone wires, to construct street railways, to lay gas pipes for the purpose of carrrying gas for heat and power, to erect poles or wires for transmitting electric heat or power, along or upon any public street or highway, or to exercise any privilege whatever, a franchise for which shall have been granted in accordance with the terms of this act, shall be commenced in good faith within not more than four months from the granting of any such franchise, and if not so commenced within said time said franchise so granted shall be declared forfeited, and shall be completed within not more than three years thereafter, and if not so completed within said time said franchise so granted shall be forfeited; provided, that for good cause the governing or legislative body may by resolution extend the time for completion thereof not exceeding three months.

Sec. 7. The grantee of every franchise or privilege granted under this act shall file a bond running to said city and county, city or town, with at least two good and sufficient sureties to be approved by such governing body, in a penal sum by it to be prescribed and set forth in the advertisement for bids, conditioned that such bidder shall well and truly observe, fulfil, and perform each and every term and condition of such franchise, and that in case of any breach of condition of such bond, the whole amount of the penal sum therein named shall be taken and deemed to be liquidated damages, and shall be recoverable from the principal and sureties upon said bond. Said bond shall be filed with such governing body within five days after such franchise is awarded, and in case said bond shall not be so filed, the award of such franchise shall be set aside, and the same may be granted to the next lowest bidder, or again offered for sale, in the discretion of said governing body.

Sec. 8. It shall be the duty of the Attorney-General, upon complaint of any municipality, or, in his discretion, upon the complaint of any taxpayer, to sue for the forfeiture of any franchise granted under the terms of this act, for the non-compliance with any condition thereof.

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

THE GARDNER ROCK DRILL.

THERE was a time in the history of railroading when hand wheel braking was regarded by trainmen as being the only reliable mechanism that could be used for the purpose of dissipating the energy of a moving train. This belief was the legitimate successor to the conditions which arose from the fact that practically no other method of braking had been used prior to that time and that, therefore, in hand braking was to be found the alpha and the omega of human knowledge in that direction. It is but natural that the mechanic, for instance, should think best of the tool with which he is most familiar—he staunch friend which has stood by him and proved faithful through years of association and toil. Hand braking was reliable, for it stopped the trains; but as railroading grew to more consequential magnitude, it became necessary that reliability should be supplemented—not displaced—by devices of the highest obtainable efficiency, the word efficiency being used in the sense implying convenience, speed, flxibility and automaticity, as well as reliability, economy in operation and readiness in emergencies. The air-brake filled all of these requirements and many others, yet, as everybody knows, the greatest obstacle to its introduction was found in the reluctance of railway train employes to discard a tried and trusted appliance for a "new fangled" innovation, however meritorious it might be.

Rock drilling presents a parallel case, for while no one will disparage the efficacy of hand drilling in its place, all will with one accord grant that machine drilling is vastly superior thereto and that it is altogether indispensable in modern methods of underground working. Up to the present time, the air drill has been generally believed to possess the nearest approach to perfection in rock-boring mechanisms for this class of work, and many conditions exist where it is probable that the use of no other form of drill will ever be seriously considered. In truth,

it is a superb mechanism, to which belongs rightfully all the credit it has earned. It has its deficiencies, however, but with a few exceptions, these are outweighed by its advantages, which can be enumerated only at the expense of useless repetition. The most noteworthy of these exceptions is found in its lack of economy as a mechanical appliance. Let us examine this efficiency—or rather this inefficiency—and see about what it amounts to.

Theoretically, a drill delivering 600 strokes in, say, 200-pound blows per minute, should require, at a very liberal estimate, not to exceed one-half a horse-power for its operation. If an efficiency of but 50 per cent. is allowed for the transmission and conversion of mechanical energy from some suitable source, such as an air line or an electric supply main to the drill, then such drill will require but a single horse-power for its operation. The theory of this assertion cannot be discredited, yet practice does not maintain it, nor does it even approach the maintenance of it so far as air drills are concerned. Moreover, when the truth of the theory is appreciated there will come a full understanding of the fact that air drills, which consume from 8 to 15 and even 20 horse-power each, are wofully extravagant machines. The Anaconda mine, with its 250 air drills, thus, as a matter of fact, develops, say, from 2,000 to 3,500 horse-power, in order that it may deliver 250 horse-power in useful drilling. Were these drills of an electrically driven type, with an efficiency of only 50 per cent between the motor and drill, approximately one-quarter of this amount of power would be required as a maximum. Furthermore, electric drills have been brought to such a high degree of perfection that they can perform any work which an air drill can do, except the ventilation of mines, which,

by the way, can be accomplished to better advantage by the use of electrically driven blowers.

The claim of the Gardner rock drill for recognition is based on the broad statements that it will work alongside the air drill in any duty with an expenditure of approximately 25 per cent. of the power consumed by the air drill.

The feasibility and economy of transmitting energy by electricity for practically every known application of power, is universally acknowledged, and in this medium is found the method adopted for operating the Gardner drill. To describe the system in a single sentence, it may be said that the Gardner drill consists of a portable electric motor delivering power to a flexible shaft, which drives a crank that gives the drawbar of the drill a spring-cushioned stroke. The principle utilized is that of the belt hammer wherein the action of a crank tightens a belt suddenly, thereby throwing the hammer. In the Gardner drill, the crank motion is such that, beginning the cycle with the drawbar withdrawn, no motion is given to the drawbar on the first quarter stroke of the crank. During the second quarter stroke or revolution of the crank, the drawbar is given the full forward stroke, while the third and fourth quarter revolutions return the drawbar to its starting position in a practically uniform motion with a slow start. The action of the crank in advancing the drawbar the full length of its stroke during the second quarter revolution of the shaft, is in this manner enabled to give four times the energy to the drill that it would possess were it driven forward by a uniform crank motion. A reducing gear that is variable in ratio according to the speed of the motor, drives the flexible shaft at 600 revolutions per minute, and as this shaft is connected directly through a beveled gearing having a one to one ratio to the shaft supporting the crank which drives the drawbar, the drill, as well delivers 600 strokes per minute. Moreover, a fly-wheel gives a mechanical storage of energy which is drawn upon during the second quarter revolution as previously described. Three speeds are given to the motor, which is of a portable type well boxed in, by the manipulation of a special controller that is both air-tight, fire-proof and water-proof, and which, moreover, contains a mechanical device that makes arcing impossible. In fact, this controller might almost be classed as an automatic device, since its mechanism prevents its being used in any other way than the proper one. The flexible shaft, which is about eight feet long and may be worked on about a three-foot radius, requires to be greased but once in seven shifts, which, if properly done, will keep it in the proper condition under continuous use.

With the exception of the casing, which is of cast iron, all parts of the drill are constructed of steel. Reciprocating motion is transmitted direct to the drawbar from the crank after the manner above described, whence it is imparted to the drill proper. Spiral springs are placed around the drawbar where they play upon a nut secured thereto and moving therewith, the outside ends of the springs being fixed with reference to the casing. This arrangement gives the drill the cushioning effect which is indispensable in reaming, or when the drill is not in contact with rock. Aside from their cushioning effects, the functions of these springs are two-fold: First, the forward spring, that is, the one nearer the drill, assists the crank in reversing the stroke of the drawbar, by reason of the release of the compression under which it was placed in the advance; and second, the energy required to compress the rear spring during the third and fourth quarter revolutions of the crank is, when released at the beginning of the second quarter revolution, added to the energy of the motor and the energy of the fly-wheel, so that the cumulated effort of the three forces will reach a maximum in the blow delivered. These springs are therefore instrumental in reversing the motions of the drawbar and drill with minimum shock or jar and with the greatest possible efficiency and ease. No possible injury can result from running the drill even at half speed when it is not in contact with rock, for the cushioning influences of the springs absorb the energy of the blows, and return it in a direction that can do no harm. If the drill be fed too fast or too close, or even if it be stalled in any manner, ample time will be given to recover without injury because of the fact that the flexible shaft is driven through an adjustable friction clutch, which will allow the motor shaft to slip the flexible shaft, in case the torque or turning effort called for in the operation of the drill exceeds a predetermined degree.

Rotation of the drill is in one direction only,as is the case with practically all other drills of whatever form or type, and it does not appear to be necessary to enlarge upon this or other mechanical features adding to convenience and reliability in operation, beyond a statement of the fact that the Gardner drill possesses every convenience held by air or steam drills, with the single exception that in sinking shafts it becomes necessary to suspend the motor overhead. For instance, removable ratchets are used. Both forward and side movement is provided, and the same columns that are fitted for air-drills are used. Its range of adjustability is extremely wide; it may be shifted sideways on the arm, or raised and lowered on the column, or swung completely around as well as underneath it, while its simplicity of mechanism is so great that the body of the drill may be opened up for inspection in any part within thirty seconds, and in fact the drill can be completely taken apart and reassembled again for operation, part by part, within the brief period of five minutes.

Thus far, the Gardner drill has been operated in practice only by the use of direct current electric motors, for the reason that alternating current motors do not possess faculties for speed control that are as satisfactory to those of direct current practice. A Gardner drill delivering 600 200-pound strokes per minute requires an electric motor having a rated capacity of one and one-half horse-power for its operation. The power actually absorbed by such a drill, under ordinary running conditions, is somewhat less than the amount stated, but it has been deemed advisable to use motors having a reserve capacity to overcome emergencies. Such a drill, which is suitable for all general work, is known as "size B," and weighs 150 pounds, while the Gardner drill in "size C" is a "slugger" for especially heavy work, and weighs 200 pounds. The latter drill will require a two horse-power electric motor for its operation, and with a two and one-half inch bit, will cut holes up to 100 inches deep. "Size B" drill will cut holes up to 60 inches deep, and its stroke is two and one-half inches; its rock cutting capacity in hard granite is from six feet to eight feet per hour, while it will cut from 16 feet to 24 feet per hour in average rock. "Size C" drill has a three-inch stroke, and delivers 500 blows per minute. The energy of each blow being approximately 600 foot pounds. It may be confidently stated that either of these drills will bore six times as much rock for a given cost of power, as any other rock drill ever invented. It is a rapid stroke drill which, although driven by electric power, is entirely free and apart from the electric current which operates the motor. Furthemore, the extreme flexibility of the electric cables for the delivery of power to the motor makes the Gardner drill of incomparable superiority to all other forms of rock drills in so far as ease and rapidity of setting are concerned.

The cost of operating the Gardner electric drill depends of course upon the cost of electric power delivered at the mine; this cost varies widely in different localities, but the cost of such electric power being known, the cost of operating the drills may be readily calculated on the basis of an average consumption of one and one-half horse-power delivered to the "size B" drill, and two horse-power delivered to the "Slugger."

The Gardner Rock Drill is manufactured and sold by the California Electrical Works, 409 Market street, San Francisco.

"Type K Integrating Meters," of the Fort Wayne Electric Works (Inc.), are described in instruction book No. 3004, to which is added discussions on testing, reading, repairing, adjusting and wiring in these wattmeters. Fort Wayne Electric Works (Inc.), Fort Wayne, Ind.